MANITOBA

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MERCURY CONTAMINATION IN FISH

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Man has used mercury since prehistoric times and even the earliest medical authors were aware of its toxic effects. Long before Christ, the Chinese formulated inks and paints from cinnabar (mercuric sulphide). They also understood the art of converting the red sulphide to metallic mercury which was an important commodity of the alchemist. The recovery of gold and silver by amalgamation dates back to the dawn of the Christian era and later created a demand for mercury throughout the world. Around 1000 A.D., Arabian physicians introduced mercurial ointments for the treatment of chronic skin diseases.

The many commercial and scientific uses of mercury with which we are now familiar depend upon properties which were largely unknown to the people of ancient times. As a metal, mercury or "quicksilver" has a number of unique and useful properties which include: liquidity at ordinary temperatures; high density and surface tension; uniform volume expansion; alloys readily; good electrical conductivity; chemical stability; and toxicity of its compounds. In this connection consider the use of mercury in thermometers, electric switches and relays, fluorescent lights, dental preparations, batteries, and the making of plastics, skin creams, mildew proof paints, seed dressings and various fungicides.

Mercury poisoning in humans has been known ever since the discovery of metallic mercury. Although organic mercury compounds may be prescribed as diuretics and inorganic compounds are used to treat a variety of skin ailments, it is well known that exposure to certain other forms of mercury can be fatal. Mercury vapours are considered extremely toxic and the methyl and ethyl mercury compounds used in seed dressings are even more toxic. It has now been substantiated that the mercury in fish taken from mercury-contaminated waters is in the toxic methyl form. Thus the great concern in the minds of many people when it was discovered that fish from certain Canadian rivers and lakes contained mercury.

The Canadian concern was founded on reports of mercury poisonings from Japan. Since the early 1950's over 100 people have died or were permanently disabled after eating mercury-contaminated fish and shellfish from Minamata Bay. Patients with the socalled "Minamata Disease" did not show the classical symptoms of mercury poisoning and it was some time until it was established the methyl mercury was the causative agent. The origin of the mercury was traced to chemical plants using mercury catalysts. A similar instance was reported at Niigata, in 1965 where 30 cases of poisoning resulted in five deaths through the daily consumption of fish containing 5 - 20 ppm mercury (wet weight).

More recently Sweden has experienced problems with mercury in freshwater fish and many areas have been closed to fishing. Although mercurial seed dressings had been responsible for declines in bird populations, contamination of fish was due to the use of mercuric slimicides in pulp mills and mercury cells in chlor-alkali plants. They established that freshwater fish should be eaten only once weekly and all fish containing more than 1.0 ppm mercury (wet weight) are banned from commerce. To date there have been no reports of mercury poisoning in Sweden from the consumption of fish.

Based primarily on Sweedish and Japanese data, it is claimed that 1 - 2 mg of methyl mercury per day will produce clinical signs of poisoning in man. Such a dose would be equivalent to 200 g of fish daily with a mercury content of 5 - 10 ppm. Studies showed that the main route of excretion of methyl mercury is via the feces rather than the urine and only minor quantities are deposited in hair. Nevertheless, hair mercury levels of 60 - 530 ppm were recorded in Japan, 7.9 ppm in Sweden, and up to 20 times the normal level of 1.5 ppm were found in Finland. The human fetus accumulates more mercury than the mother-to-be leading to congenital cases of mercury poisoning born of mothers having no symptoms of poisoning. Some of the recorded symptoms of methly mercury poisoning in man are:

numbness in extremeties;
numbness around mouth and nose;
constriction of visual field;
impaired hearing;
slurred speech;
impaired muscular co-ordination;
hysteria;
flaccid paralysis;
coma followed by death.

Turning now to the Canadian situation, you will recall that this matter came to life on November 27, 1969 when the Saskatchewan Government reported that fish taken from the Saskatchewan River contained abnormal amounts of mercury. Knowing that these fish could be hazardous to human health and that their sale could seriously jeopardize the entire Canadian freshwater fishery, the Federal Department of Fisheries and Forestry immediately placed all fish from the Saskatchewan River System under detention. The Freshwater Institute was asked to set up a laboratory for analyzing fish and to investigate the problem. We immediately began to analyze fish on a daily basis for the Federal Fisheries Inspection Branch and only fish with less than 0.5 ppm mercury were released for sale. All other fish were incinerated to ensure that they could not be eaten by humans, animals, or wildlife. Inasmuch as the Freshwater Fish Marketing Corporation was the sole buyer of fish from the area, there was no problem to screen all fish coming from fishermen. The Winnipeg Laboratory of the Department of Fisheries and Forestry took over the analysis of all commercial fish for inspection purposes on June 1, 1970, which enabled the Freshwater Institute to devote more time to investigating the extent and cause of the problem.

Even though we are not a heavily industrialized nation and could not be considered a major user of mercury, we are nevertheless faced with nation-wide contamination of fish with mercury. Results of a national survey have revealed so far that fish from the following areas contain unsafe levels of mercury (i.e. more than 0.5 ppm Hg in wet muscle): Howe Sound; Pinchi L.; the North and South Saskatchewan Rivers; Cedar L.; L. Winnipeg; the Red and Assiniboine Rivers; some of the Nelson River System; Hudson Bay; the Winnipeg English – Wabigoon Rivers System; Marathon and Thunder Bay areas of L. Superior; the St. Clair River; the Detroit River; the western end of L. Erie; certain lakes in northwestern Quebec; the St. Lawrence River and a number of its tributaries including the Ottawa River; and the harbour area of Dalhousie, N.B. Results for these areas are summarized in Tables I to VII and indicate the degree as well as the extent of mercury contamination in these and neighbouring waters.

Looking now to possible sources of mercury losses to the environment, 300,000 lb. mercury were used in Canada in 1969 and two-thirds of this amount was used by chlorine plants. In these plants mercury is used as a cathode for the electrolysis of saturated brine to produce chlorine and sodium hydroxide, hence the term "chlor-alkali plant." It is estimated that in this process close to 1/3 lb. mercury can be lost for every ton of chlorine produced. Plants with a daily production of 100 tons chlorine or more are not uncommon and it is easy to calculate that such a plant could consume around 10,000 lb. mercury per year most of which would be discharged to the environment mainly in waste water.

The chlor-alkali plants in Canada are listed in Table VIII and you will notice that contaminated fish have been found wherever there is a mercury cell chlorine plant. I would emphasize that all such plants in Canada were notified early in 1970 that immediate steps had to be taken to prevent any discharges of mercury to the environment and that they would be responsible for cleaning up any areas that had become contaminated from their effluents. The response from the chlorine industry has generally been very favourable.

Mercury compounds have been widely used in the pulp and paper industry as slimicides. Slimicides are used in wood-preparation areas and in the vicinity of paper machines to control slime fungi which are a nuisance in mill operation. Organic mercury compounds like phenylmercuric acetate are extremely effective against these slimes. During the last 10 years, many countries including Canada have for the most part discontinued using these compounds owing to regulations preventing the use of mercury containing papers in the wrapping and packaging of foods. Only about half a dozen Canadian mills were still using mercury slimicides in January 1970 and all have now received formal notification that their use must be discontinued.

Seed dressings also contain highly toxic mercury compounds and their use is declining in Canada and elsewhere. Although these compounds have caused serious problems with birds (e.g. Sweden and Alberta), we have no evidence yet that they have affected fish.

The use of mercury in the recovery of gold and silver is now relatively unimportant.

Inasmuch as the United States is probably the world's leading consumer of mercury, the breakdown of consumption for 1969 shown in Table IX indicates other possible sources of mercury pollution. For example, more and more mercury is being used in batteries, lamps, switches, electrical instruments, and as catalysts in the manufacture of chemicals, particularly those used in the making of plastics.

It has been found that when mercury is discharged into a river or lake there is no appreciable uptake by aquatic plants and most of it goes to the bottom and stays there. However some of it is gradually released into the water as organic mercury compounds by bottom organisms where it can enter the food chain and be taken up directly by fish. Accumulation can be rapid but elimination is slow. Kidney, liver and gill tissue contain highest mercury concentrations and lowest levels appear in muscle, bone and skin. Levels in pike muscle can be 3000 times the concentration in the water. Pike and other predacious species contain the highest mercury levels (see Table II) but values for muscle tissue vary considerably even for the same species. In wild fish, higher concentrations are generally found in larger or older fish.

Even though mercury compounds are highly toxic, there are no reports of fish kills due to mercury pollution. Tests are proceeding at the Freshwater Institute to determine the toxic effects of mercurials on fish and whether they interfere with reproduction.

Other studies at the Freshwater Institute include the use of caged fish and clams as indicators of mercury pollution and mercury levels throughout the aquatic food chain. I already mentioned that a national survey of mercury and pesticide residues in Canadian

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fish is continuing and hopefully analyses for other heavy metals will be added in the near future. Our analytical procedure for determining total mercury in fish tissue has been most successful and we are about to release a reliable procedure for determining organic or methyl mercury in fish. The incorporation of mercury contaminated fish into animals feeds is an important question and tests are well advanced in this regard. You will notice in Table II that the reduction of Cedar Lake pike to fish meal resulted in a mercury loss of only about 25%.

Analyses of bottom sediments have revealed very insignificant deposits of mercury downstream from chlor-alkali plants which through mobilization by microorganisms will continue the pollution problem even though effluents no longer contain mercury. The rate and degree of mobilization of these deposits is being actively investigated in order to estimate clearing times and what course of action is required. A reliable figure for the half-life of methyl mercury in fish muscle is also required.

I would also point out that we are unable as yet to explain why some areas contain mercury contaminated fish. Minor users of mercury will have to be investigated as well as the cury levels in fish arising from natural sources.

In conclusion Mr. Chairman, we have a serious problem which will require much time and effort to resolve. Furthermore, we cannot expect the solution to be rapid. In the meantime, American and Canadian inspection agancies are taking all necessary precautions to ensure that contaminated fish do not enter the market.

I would mention that scientists at the Freshwater Institute have and are receiving a great deal of assistance and cooperation from a number of Federal and Provincial agencies in Canada, several Universities, and our neighbours in the United States.

TABLE I.

MERCURY IN B. C. FISH

Species	Location	Ave. PPM Hg
Crabs	Squamish	1.55 - 13.4
"	Fraser River Flats	0.19
"	West Vancouver	0.14
"	Tofino	0.02
Flounder	Squamish	1.00 - 1.42
"	Fraser River Flats	0.23
"	Hectate Strait	0.11
Herring	Squamish	0.14 - 0.30
"	Prince Rupert	0.07
Lake Trout	Pinchi Lake	2.86
Rainbow Trout	Tezzeron Lake	0.04

TABLE II.

MERCURY CONTENT OF FISH FROM THE SASKATCHEWAN RIVER SYSTEM

Location	Species	Number of Samples	Ave PPM Mercury
Downstream of Edmonton	Pike	1	1.06
"	Walleye	5	0.95
"	Goldeye	5	0.59
"	Burbot	14	0.38
Upstream of Saskatoon	Pike	4	0.53
Downstream of Saskatoon	Pike	5	5.86
"	Sucker	1	4.07
"	Goldeye	4	2.26
"	Sauger	1	4.37
Squaw Rapids	Pike	9	1.40
Cedar Lake	Pike	44	0.68
"	Pike (meal)	2	1.98
"	Walleye	13	0.55
"	Sauger	2	0.59
"	Whitefish	7	0.11
"	Cisco	7	0.11

TABLE III.

MERCURY CONTENT OF LAKE WINNIPEG FISH

Area	Northern Pike	Walleye	Sauger	Sheepshead	Yellow Perch
			(ave. ppm Hg)		
Red River	0.45	0.43	0.56		0.67
Hecla Island	0.57	0.32	0.63	0.74	0.70
B. Bear Island	0.39	0.19	0.60		
Sturgeon Bay	0.37	0.39	0.46		
Berens River		0.28	0.34		
Poplar Point	0.31	0.26	0.37		
Long Point	0.58	0.33	0.40		
Grand Rapids	0.40	0.33	0.43		
Playgreen Lake	0.29	0.26			

TABLE IV.

MERCURY CONTENT OF FISH FROM MANITOBA LAKES

		Number of Samples	Ave. PPM Hg
Lake Winnipegosis	Sauger	2	0.13
	Northern Pike	5	0.13
	Whitefish	1	0.03
	Sucker	2	0.04
	Walleye	3	0.16
	Yellow Perch	1	0.13
Lake St. Martin	Walleye	1	0.21
	Yellow Perch	1	0.12
	Sucker	1	0.07
	Northern Pike	1	0.23
Lake Manitoba	Sauger	3	0.14
	Sucker	3	0.06
	Walleye	3	0.11
	Northern Pike	4	0.31
	Yellow Perch	1	0.07
Dauphin Lake	Walleye	1	0.11
Cedar Lake	Northern Pike	44	0.68
	Walleye	13	0.55
	Cisco	7	0.11
	Whitefish	7	0.11
	Sauger	2	0.59
Moose Lake	Cisco	2	0.04
	Whitefish	2	0.08
	Northern Pike	2	0.15

TABLE V. - a

MERCURY CONTENT OF RIVER FISH

		Species	Ave PPM Hg
Assiniboine River			
		Pike	0.29
		Walleye	0.55
		Sauger	1.21
		Sucker	0.46
Red River	Halstead, U.S.	Pike	1.57
		Carp	0.45
		Sucker	0.57
	Emerson	Pike	1.11
		Carp	0.22
		Sucker	0.27
	St. Norbert	Pike	0.86
		Sucker	0.11
	Lockport	Pike	0.68
		Walleye	0.46
		Sauger	0.63
	Selkirk	Pike (Large)	0.84
		Pike (Medium)	0.44
		Sauger	0.35
		Sucker	0.09
Nelson River			
	Playgreen Lake	Pike	0.34
		Walleye	0.27
		Whitefish	0.12
	Little Playgreen Lake	Walleye	0.61
	Cross Lake	Pike	0.44
		Walleye	0.43
		Whitefish	0.07
	Pipestone Lake	Pike	0.51
		Walleye	0.41
	Sipiwesk Lake	Pike	1.16
		Walleye	0.79
		Whitefish	0.11

TABLE V. - b

MERCURY CONTENT OF RIVER FISH

		Species	Ave PPM Hg
Winnipeg River			
	Pine Falls	Pike	0.80
		Walleye	0.57
		Sauger	0.71
	Eleanor Lake	Pike	1.42
		Walleye	1.43
		Whitefish	0.24
		Burbot	0.33
	Dorothy Lake	Pike	0.95
		Walleye	1.52
		Perch	0.55
		Whitefish	0.25
	Boundary Falls	Pike	2.91
		Walleye	1.69
		Burbot	2.12
	Tetu Lake	Pike	1.32
		Sucker	0.90
	Gun Lake	Pike	1.01
		Walleye	1.42
	Lake of the Woods	Pike	0.38
		Walleye	0.39
		Perch	0.29
English - Wabigoon River			
	Umfreville Lake	Pike	2.68
		Walleye	3.89
		Whitefish	1.17
	Lount Lake	Pike	5.36
		Walleye	2.47
	Clay Lake	Pike	8.03
		Walleye	7.71
		Whitefish	3.27
		Burbot	12.1
"Controls"			
	Eagle Lake	Pike	0.30
		Walleye	0.24
	Thunder Lake	Walleye	0.31
		Whitefish	0.04

TABLE VI.

MERCURY LEVELS FROM HUDSON BAY

Species	Location	Number of Samples	Ave PPM Hg
Beluga - meat	Hudson Bay	17	0.66
Beluga - Muktuk	"	5	0.18
Beluga - meal	"	1	2.69
Sucker	Mouth Churchill River	1	.22
Pike	"	1	.24
Whitefish	"	1	.12
Cisco	"	1	.12
Capelin	"	1	0.04
Seal - meat	"	1	0.15

TABLE VII.

MERCURY CONTENT OF FISH FROM EASTERN CANADA

Species	Location	Ave PPM Hg
Pike	Thunder Bay Harbour, Lake Superior	0.75
	Marathon Harbour, Lake Superior	1.51
Walleye	Lake Huron (south end)	1.34
Coho	Lake Huron (south end)	0.16
Pike	Lake St. Clair	1.40
Perch	Lake Erie (193)	0.23
Walleye	Lake Erie	0.41
Pike	Lake Ontario	0.54
Pike	Ottawa River	0.94 - 1.83
Pike	St. Lawrence River	0.76 - 1.85
Herring	Atlantic Coast	0.02 - 0.09
Herring meal	" "	0.02 - 0.14
Cod	" "	0.09
Flounder	" "	0.10
Crab	" "	0.10
Lobster	" "	0.08 - 0.20
Oyster	" "	0.02 - 0.14

TABLE VIII.

CHLOR - ALKALI PLANTS IN CANADA

* FMC Chemicals Ltd.	Squamish, B.C.
Cominco Ltd., (closed 1969)	Tadanac, B.C.
Hooker Chemicals Ltd.	Plants: Nanaimo, B.C. North Vancouver, B.C.
Canadian Chemical Co., division of Chemcell Ltd., (closed 1969)	Two Hills, Alta.
* Interprovincial Cooperative	Saskatoon, Sask.
Dryden Chemicals Ltd.	Brandon, Man.
* Dryden Chemicals Co. Ltd.	Dryden, Ont.
* Down Chemical Ltd.	Thunder Bay, Ont.
* American Can. Co.	Marathon, Ont.
Brown Forest Industries Ltd.	Espanola, Ont.
Dow Chemical Ltd.	Sarnia, Ont.
* Chlorine No. 1	
Chlorine No. 2	
* Chlorine No. 3	
* C.I.L.	Hamilton, Ont.
* C.I.L.	Cornwall, Ont.
* C.I.L.	Shawinigan, Que.
* C.I.L.	Dalhousie, N.B.
* Aluminum Co. of Canada	Arvida, Que.
* Standard Chemical Co. Ltd.	Beauharnois, Que.
* Shawinigan Chemicals Ltd. (closed about 1968)	Shawinigan, Que.
* Domtar	Lebel - sur - Quevillon, Que.
* Canso Chemicals (to open 1970)	New Glasgow, N. S.

* use mercury cells.

TABLE IX.

U. S. MERCURY CONSUMPTION FOR 1969

	(Thousands of lbs.)
Chlor - alkali industry	1572
Electrical apparatus	1382
Paint	739
Instruments	391
Catalysts	221
Dental preparations	209
Agriculture	204
General laboratory use	126
Pharmaceuticals	52
Pulp and paper making	42
Amalgamation	15
Other	1082
TOTAL	6035

Source: U. S. Department of Interior, Bureau of Mines.